18. Obtain Dirac free particle solution. Also discuss about probability density and current density.

19. Derive an Dirac equation in covariant form and explain in detail.

20. What are number operators? Outline the creation and annihilation operators of bosons and give their importance.

NOVEMBER/DECEMBER 2025

23PPH31 — QUANTUM MECHANICS — II

Time : Three hours Maximum : 75 marks

SECTION A — (10 × 2 = 20 marks)

Answer ALL questions.

1. Write the relation of scattering cross-section and scattering amplitude.

2. State Optical theorem.

3. What are Einstein coefficients?

4. What are selection rules for dipole transition?

5. Write Klein-Gordon equation. What are its shortcomings?

6. Write the magnetic moment of electron as obtained by Dirac's equation.

7. Define Bilinear covariant.

8. What is probability density?

9. What are creation and annihilation operator of photons?

10. What is the difference between first and second quantizations?

SECTION B — (5 × 5 = 25 marks)

Answer ALL questions.

11. (a) Discuss the scattering by screened coulomb potential and derive Rutherford's scattering formula.

Or

(b) Explain the scattering length and effective range theory for low energy scattering.

12. (a) State and prove Fermi-Golden rule for the rate of transition to a continuum of final states due to constant pertubation.

Or

(b) How the sudden approximation can be used to determine the transition probabilities of a system when its Hamiltonian changes rapidly?

13. (a) Derive Klein-Gordon equation for a relativistic free particle and then obtain associated probability density and current densities.

Or

(b) What are negative energy states? Give its significance.

14. (a) Explain the properties of gamma matrices.

Or

(b) Elaborate on Feynman Theory of positron.

15. (a) Define the classical field equation in Hamiltonian form.

Or

(b) Briefly explain the Fock states.

SECTION C — (3 × 10 = 30 marks)

Answer any THREE questions.

16. Discuss the method of partial wave analysis to get the scattering amplitude.

17. Explain the time development of states using time dependent perturbation theory and obtain the probability amplitude for the system with the perturbation in constant time.